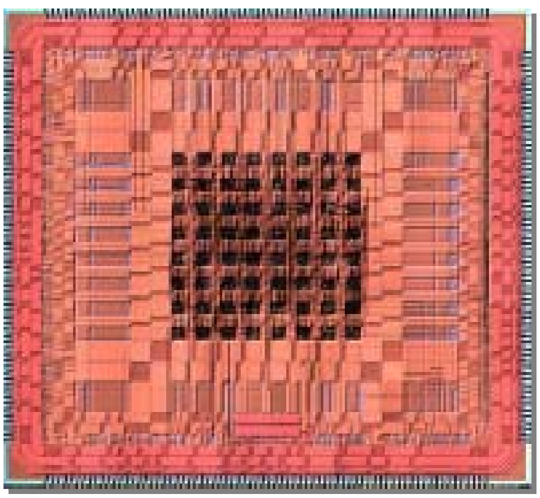
Xyce™
News
Note

Xyce™ Parallel Simulation of the Permafrost ASIC



On September 17th, 2003, the **Xyce**™ team at Sandia National Laboratories demonstrated the efficacy of its modern solution methods by performing a parallel simulation of the W76-1 Permafrost Application Specific Integrated Circuit (ASIC). This ASIC contained in excess of 200,000 MOSFET transistors, modeled by the BSIM3 MOSFET analog model. Notable in this simulation is the use of a new *homotopy* algorithm, provided by the **NOX**/**LOCA** library (part of the **Trilinos** solver suite) and a *homotopy-enabled* BSIM3 model – *two new features unique to* **Xyce** *among circuit simulation codes* - that were crucial in the ability to perform this calculation. This demonstrated capability is critical to the future electrical modeling and simulation needs at Sandia where environmental effects on critical electrical components can now be simulated.

The ASIC device is a digital circuit which is key to understanding the difficulty associated with this calculation. As part of performing a transient simulation of this digital circuit, the initial conditions or the so-called *DC Operating Point* (DCOP) must first be determined. However, there are many potential “states” that the circuit may adopt for the DCOP and this non-uniqueness of the solution presents extreme difficulties for both the nonlinear and linear solution methods. In fact, it is often extremely difficult if not impossible to determine the DCOP for these circuits using conventional Newton-based approaches. Nevertheless, using the new homotopy approach dramatically transforms the DCOP calculation into a much more tractable problem allowing for the use of parallel Krylov iterative methods for the underlying linear sub-problems. Thus, these tools enable the application of large-scale parallel computing to digital and analog simulations of critical Sandia components.

About Homotopy Algorithms

Homotopy algorithms work by transforming a difficult nonlinear problem to a related but much easier problem. The relationship between the problems is governed by a single parameter that, as it is varied from a value of 0 to a value of 1, maps between the simple and the hard problems, respectively. Thus, **Xyce** begins with the simple problem and gradually increases the value of the homotopy parameter, solving successively harder problems, until it reaches 1 and thus a solution to the original problem. At each solve, the previous solution is used as an initial guess and so the current problem is easier to solve than it would have been starting from a zero initial guess.

The key, however, to successful homotopy methods is in determining which parameter or parameters to vary. For MOSFET models in **Xyce**, two parameters are actually used in combination to achieve the homotopy model. The implementation for the BSIM3 MOSFET model in **Xyce** is unique and gives Sandia a capability not available from any other code.

About **Xyce**™

Xyce is a new circuit simulation code designed from the ground-up as a parallel tool in the most general sense, that is, a message passing parallel implementation, which allows it to run efficiently on the widest possible number of computing platforms. These include serial, shared-memory and distributed-memory parallel as well as heterogeneous platforms.

A DoE-ASCI funded project, the **Xyce** Parallel Electronic Simulator development has focused on improving the capability over the current state-of-the-art in the following areas:

- Capability to solve extremely large circuit problems by supporting large-scale parallel computing platforms (up to thousands of processors). Note that this includes support for most popular parallel and serial computers.
- Improved performance for all numerical kernels (e.g., time integrator, nonlinear and linear solvers) through state-of-the-art algorithms and novel techniques.
- Support for modeling circuit phenomena at a variety of abstraction levels (device, analog, digital and mixed-signal) in a rigorous and tightly coupled manner, allowing for timely, full-system solutions.
- Object-oriented code design and implementation using modern coding-practices that ensure that the **Xyce** Parallel Electronic Simulator will be maintainable and extensible far into the future.
- Improved "usability" through improved analysis control (e.g., variable solution checkpoint/restart capability) that improves the design workflow.

For more information on **Xyce**, please visit http://www.cs.sandia.gov/Xyce

About **Trilinos**

The Trilinos Project is an effort to develop and implement robust, parallel, numerical solution algorithms using modern object-oriented software design, while still leveraging the value of established numerical libraries such as PETSc, Aztec, the BLAS and LAPACK. It emphasizes abstract interfaces for maximum flexibility of component interchanging, and provides a full-featured set of concrete classes that implement all abstract interfaces.

For more information on **Trilinos**, please see http://software.sandia.gov/trilinos

About **NOX**/**LOCA**

NOX is short for Nonlinear Object-Oriented Solutions, and its objective is to enable the efficient solution of nonlinear equations such as those arising in implicit PDE and DAE simulation codes. NOX is designed to work with any linear algebra package and to be easily customized. For more information, please see http://software.sandia.gov/nox/

LOCA is a generic continuation and bifurcation analysis package that is designed for large-scale applications. The algorithms are designed with minimal additional interface requirements over that needed for a Newton method to reach an equilibrium solution. **LOCA** is built upon the **NOX** nonlinear solver package. The algorithms in **NOX** are generic and written to the NOX::Abstract::Group and NOX::Abstract::Vector, which provide abstract interfaces to the linear algebra, data structures, and nonlinear equations to be solved. **LOCA** uses the **NOX** interface and extends it via additional abstract groups that provide the interface needed for continuation and bifurcation tracking, such as setting parameters and computing derivatives with respect to parameters. For more information, please see http://software.sandia.gov/nox/loca_overview.html

Trademark Information

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